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Challenging Old Ideas: How supplemental effects student confidence and learning and adding a key piece to understanding the origin of an important crop, kenaf, Hibiscus cannabinus L. and understanding how supplemental videos effect student confidence and learning

Justin Hendy
University of Tennessee, jhendy@vols.utk.edu

Challenging Old Ideas:

Adding a key piece to understanding the origin of an important fiber crop, kenaf, *Hibiscus cannabinus* L. and understanding how supplemental videos effect student confidence and learning

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Abstract

This is a two-part thesis that focuses on identifying the center of origin for kenaf, *Hibiscus cannabinus* L., and the effects of supplemental videos on student confidence and learning. Kenaf, *Hibiscus cannabinus*, is an important fiber crop worldwide that lacks genetic studies to identify its CWR and center of origin. Maximum likelihood phylogenies were created from sequence data obtained from accessions from the USDA National Plant Germplasm System. Prior studies have shown East Africa as the center of origin for kenaf. This study shows support that the center of origin for kenaf should include South-Central Africa. The data also show conflicting evidence for both a single and multiple domestication events for kenaf. The second part of this thesis analyses the effects of student engagement with optional supplemental videos on confidence in scientific skills, perception of future success, perception of instructor, and academic performance. Students who watched the supplemental videos performed significantly better on a common assessment than students who did not watch the videos. However, the students who watched the videos also self-reported lower levels of confidence, perception of future ability, and perception of their instructor. This suggests that the videos may have led students to question their knowledge compared to students who didn't watch the videos, despite their positive impact

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Introduction

This thesis consists of two separate studies. The first study identifies which geographic regions in Africa are potentially a part of the center of origin for kenaf, *Hibiscus cannabinus* L. The second study analyzes the effects of student engagement with supplemental videos on confidence and academic performance.

The first chapter addresses the issue that the center of origin is currently not agreed upon for kenaf. Kenaf is a major fiber crop worldwide and plant breeding is difficult without first identifying its center of origin. The center of origin consists of wild populations that can be used to breed wild alleles with different traits into the cultivated populations to improve its cultivation. Most studies have focused on East Africa as the center of origin while not fully analyzing other regions of Africa. This study aims to include samples from both Northwest and South-Central Africa to identify if they are potentially a part of the center of origin for kenaf. This study will also determine if kenaf underwent a single or multiple domestication events. Currently, kenaf is thought to have a single domestication event, but data to support this is lacking.

The second chapter examines how supplemental videos influence student academic performance and confidence levels. Many instructors are starting to use supplemental materials to reach students outside of the classroom with little knowledge of what it does to student confidence and academic performance. Little research has linked supplemental videos to student confidence. They also offer conflicting results as to whether they increase academic performance. This study will show how supplemental materials effect student confidence towards skills in that class, confidence in their future ability in biology, perception towards their instructor, and academic performance.

Chapter One

Evaluating kenaf (*Hibiscus cannabinus*) germplasm for insight into its center of origin and domestication

Abstract

Identifying the crop wild relatives (CWR) for an agricultural plant is important as it delineates the plants' center of origin, which opens the possibility of interbreeding wild alleles into the cultivated lines. Kenaf, *Hibiscus cannabinus*, is an important fiber crop worldwide that lacks genetic studies to identify its CWR and center of origin. Using accessions from the USDA National Plant Germplasm System, two single-copy nuclear genes were amplified and sequenced. These sequences were used to construct maximum likelihood phylogenies. These phylogenies show support for East and South-Central Africa as the likely center of origin for kenaf, and they refute the hypothesis of Northwest Africa as being the center of origin. They also show conflicting evidence for both a single and multiple domestication events for kenaf. Although this work suggests a possible origin a more comprehensive sampling of both wild and cultivated types from across West and East Africa would definitively rule out other possible centers of origin or number of domestication events. Prior studies on kenaf origin use limited data from South-Central Africa and lack the ability to conclude its importance to identifying kenaf's CWR. This study shows support that the center of origin for kenaf should include South-Central Africa.

Introduction

Two important concepts in understanding domestication are those of centers of domestication and centers of origin. The center of domestication for a plant is the region in which it was first domesticated and subsequently spread out from (Harlan 1971). The center of origin for a plant is the region in which the crop wild relatives (CWRs) are found (Wilson and Menzel 1964). These two centers are often the same region, but do not have to be the same, such as when a plant was found in one region and spread naturally or artificially to another where it was cultivated.

Agriculture, through the domestication of plants, developed independently in more than one geographic region (Gepts 2004, Vavilov 1926). Vavilov (1926) first suggested this by pointing to certain geographic regions that displayed a high level of morphological diversity for various crops. The exact number and borders of these centers of agriculture are not fully understood or accepted (Peake and Fleure 1927, Vavilov 1926, Vavilov 1951, Gepts 2004). The centers of agriculture do not apply to all crop plants and an understanding of each crop's domestication is needed to study domestication traits in that crop (Gepts 2004).

The center of origin for a crop is important to know to identify its CWRs. One way to distinguish the center of origin is to identify where there is a wide range of wild types found in the region (Peake and Fleure 1927). These wild type populations should exhibit the greatest phenotypic and genotypic variation of any population of the plant (Wilson and Menzel 1964, Harlan 1971). It is also possible to identify the center of origin without using levels of diversity by creating a comprehensive phylogeny. Such a phylogeny would need to include wild and cultivated populations for the entirety of its geographic range to ensure full coverage of the plants' genotypes. Accessions that diverge early in the phylogeny may represent the geographic region for the center of origin and suggest that they are the CWRs for the crop.

This same comprehensive phylogeny can also be used to estimate the number of domestication events that the crop went through over is evolutionary history. The most commonly used hypothesis states that most domesticated plants underwent multiple domestication events (Meyer 2012). However, increasing evidence points to this possibly being the exception and not the rule as most food crops show a single domestication event (Meyer 2012). A phylogeny with wild types diverging from the root of the tree sister to all the cultivars shows evidence for a single domestication event as demonstrated with scarlet runner bean, (*Phaseolus coccineus* L.) (Guerra-Garcia et al. 2017). A phylogeny with multiple clades of wild types, each of which is sister to a different clade of cultivars, would show evidence of multiple domestication events as demonstrated with strawberries (*Fragaria* spp.) (Qiao et al. 2016). Better understanding of how crop species such as Kenaf were domesticated will help to identify its CWR and center of origin. This knowledge would make it easier for plant breeders to breed wild alleles with different traits into the cultivated population.

Kenaf, *Hibiscus cannabinus* L. Malvaceae, is a good model organism to show the importance of understanding the center of origin for a crop. Kenaf is one of the major fiber crops in the world currently grown primarily in China, India, and southeast Asia. Kenaf is a multiuse crop mainly used to make rope or as pulp to make paper or other biomass products (Alexopoulou 2015). Research on kenaf increased during the 1940s when World War II made it difficult for many countries to obtain Jute, *Corchorus* spp., which was the main natural fiber crop in the world (BioKenaf 2007, Dempsey 1975). Currently a large amount of research is focused on improving kenaf yield. One way to improve plant breeding is by breeding useful wild alleles into the cultivated populations. This is difficult for kenaf as it currently has no agreed upon CWR. This is due in part to a lack of consensus on the center of origin. Identifying kenaf's center of origin would allow the possibility of interbreeding wild alleles into the cultivated lines.

Early studies using limited geographical sampling concluded that India is a potential center of origin due to kenaf growing outside of cultivation throughout the country (Royle 1855, McCann 1952, Crane 1947). However, kenaf is known to easily escape cultivation; and more modern historical studies show kenaf spreading to India from Africa between 1800 and 1900 (BioKenaf Booklet 2007, Dempsey 1975). Modern studies using genetic data have shown that Indian accessions are more genetically like African wild types than cultivars from other parts of the world (Satya 2013). These studies showed that India is not the center of origin for kenaf and was most likely introduced to India during the early stages of its domestication (Satya 2013).

Using ethnobotanical data from Africa showing domesticated kenaf in Sudan before 4000 BC, it has been suggested that the center of origin is likely in eastern Africa (Murdock 1959, Wilson and Menzel 1964). Eastern Africa includes the current geopolitical boundaries of Sudan, South Sudan, Kenya, and Tanzania (Figure 1.4). Extensive work with herbarium specimens from Africa showed a greater morphological diversity in accessions from Angola in western Africa (Wilson and Menzel 1964). West Africa includes the current geographic range of Angola. However, in that same paper, it is noted that wild types are found in eastern Africa in Kenya and that perhaps kenaf spread from Angola to Kenya and Sudan or just as likely, in the opposite direction (Wilson and Menzel 1964). Accessions from both south-central Africa in the current geographical range of Zambia and Northwest Africa in the current geographical ranges of Ghana, Nigeria, and Guinea were designated as wild types or lacked a designation. These morphological studies helped focus future genetic research on African kenaf populations.

With the center of origin agreed to be in Africa, genetic studies show eastern African accessions diverging closer to the root of a phylogeny of 84 kenaf accessions, leading them to conclude that East Africa is the center of origin (Qi 2011, Xu 2013, Zhang 2013). These studies included several non-African accessions designated as wild types that form a paraphyletic group sister to the cultivar accessions. None of these studies used any accessions from West Africa and only a single accession was included from Zambia, which was sister to the East African accessions (Xu 2013). There is support for East Africa as the center of origin, but it is not possible to conclude if West and South-Central Africa are also a part of the center of origin. Genetic studies assessing kenaf CWR lack a complete sampling of wild types from across Africa to make a definitive conclusion as to its center or origin.

The goals of this paper are to analyze existing kenaf germplasm from the USDA National Plant Germplasm System (NPGS) to create a phylogeny (USDA 2019). This phylogeny will be used to assess the likely center of origin and number of domestication events for kenaf. Since most crops are found to show a single domestication event it is expected to be the same for kenaf. The expected phylogeny will show a monophyletic clade of wild accessions diverging near the root of the tree with all cultivars in a monophyletic clade sister to the wild clade. This will identify the center of origin for kenaf as being the geographic range of the monophyletic wild clade and will also support a single domestication event.

Methods

Both domesticated cultivars and wild accessions of kenaf totaling 42 lots with 50 seeds each were obtained from the NPGS (USDA). NPGS collection data designated the 42 lots as follows: 7 wild types, 24 cultivars, and 11 with no designation. All seven wild types were from African countries. The 24 cultivars were from many countries around the world, as listed in Table 1.1. The 11 undesignated lots included African and non-African countries. A total of 19 lots were collected in Africa. All 42 accessions used in the study are listed in Table 1.1.

All lots were grown in the University of Tennessee greenhouses. The plants were grown until they produced at least their first true leaves. These first true leaves were collected and stored at -80 °C until used for DNA extraction. DNA was extracted using a Qiagen DNeasy Plant Mini Kit following manufacturer's protocol (Qiagen 2012).

Each lot underwent PCR to amplify two different nuclear gene regions; GBSSI-2A (granule-bound starch synthase 2A) and ADH-4 (alcohol dehydrogenase 4). Primer development was carried out by Randy Small (Unpublished). A list of primers used can be found in Table 1.2. All PCR reactions (25 µl) contained the following: 16.375 H_2O, 2.5 µl 10x buffer, 2 µl dNTPs, 1 µl $MgCl_2$, 0.5 µl BSA, 0.25 µl for each primer, 0.125 µl Taq polymerase, and 2 µl of kenaf DNA. The PCR conditions used for GBSSI-2A were 94°C for 3 minutes, 40 cycles of 94° for 30 seconds, 60° for 30 seconds, 72° for 2 minutes. The PCR conditions used for ADH-4 were 94° for 3 minutes, 40 cycles of 94° for 30 seconds, 59° for 30 seconds, 72° for 2 minutes.

Products from PCR reactions were cleaned using ExoSAP-IT (USB). Purified PCR products were sequenced using ABI Prism Big Dye Terminator Cylce Sequencing kits v. 3.1 (Applied Biosystems). The thermal cycle parameters were 40 cycles of 96°C for 30 seconds, 15 seconds at the annealing temperatures listed in Table 1.2 for each primer, 60°C for 4 minutes. Sequenced products were read on an ABI 3730 capillary electrophoresis instrument at the UT Genomic Core (UT Genomics).

Returned sequences were edited and trimmed using Sequencher version 5.1 (Gene Codes Corporation). Forward and reverse sequences were merged to create a consensus sequence for each accession. All consensus sequences were trimmed to create a common start and end nucleotide to compare sequences against each other. The trimmed consensus sequences were aligned using default parameters for MUSCLE version 3.7 on the CIPRES Scientific Gateway (Edgar 2004, Miller 2010).

Maximum likelihood analysis was performed on these aligned sequences to create gene trees using default parameters of RAxML version 8.2.12 on the CIPRES Scientific Gateway (Stamatakis 2014, Miller 2010). The default automatic model selection within RAxML used the GTR (Generalized Time Reversible) substitution matrix and the likelihood of the final tree was evaluated and optimized with GAMMA. The three gene trees created included: one gene tree for GBSSI-2A, one gene tree for ADH-4, and one combined tree using concatenated ADH-4 and GBSSI-2A data. Due to the two gene tree topologies being nearly identical it was possible to create the concatenated tree without one gene tree heavily influencing the other. All trees were rooted using *H. sudanensis*, a closely related species in *Hibiscus* section *Furcaria* (Wilson 1999).

Based on clades formed for each of the three phylogenies, accessions were divided into three groups labeled A, B, and C. Nucleotide diversity, Pi, (Nei 1987) of each group was calculated for each of the three datasets used to create the phylogenies. Nucleotide diversity was calculated using the PopGenome package in R (Pfeifer 2014, R 2018).

Results

The GBSSI-2A gene region analysis amplified approximately 1878 base pairs. This region contained 4.7% of nucleotides as SNPs (single nucleotide polymorphisms) with a total of 88 SNPs as well as 7 indels (insertion deletions). The gene tree constructed with GBSSI-2A showed two monophyletic clades (Figure 1.1). One clade with high support, Group A, consists of undesignated or cultivar designated accessions from both African and non-African countries. One wild designated accession from Northwest Africa is embedded within the Group A clade, marked with an asterisk. Branch length throughout Group A is short, indicating identical sequences or very few differences. Nucleotide diversity for Group A is 0.00009. The other monophyletic clade of this tree consists of two distinct groups. Group B includes six accessions designated as wild and one accession without a designation. All Group B accessions are from East and South-Central Africa. Group B is paraphyletic as it consists of two separate clades with Group C. Group C consist of three accessions designated as cultivars. Branch lengths within group B are very long when compared to Groups A and C. Nucleotide diversity is 0.01 for Group B and 0.0003 for Group C.

The ADH-4 gene region analysis amplified approximately 1141 base pairs. This region contained 3.4% of nucleotides as SNPs with a total of 39 SNPs as well as 9 indels. The gene tree constructed with ADH-4 showed two main groups (Figure 1.2). Group A forms a highly supported monophyletic clade which includes Group C. This clade consists of undesignated or cultivar designated accessions from both African and non-African countries. The same wild designated accessions from Northwest Africa that came out in Group A for the GBSSI-2A tree came out in this ADH-4 tree, marked with an asterisk. Only two accessions had any variable branch length within the Group A clade. This shows that most sequences within Group A were identical for this gene region. Nucleotide diversity for Group A is 0.0003. Group B consists of the same seven East and South-Central African accessions as in the GBSSI-2A tree and is a paraphyletic group that diverges near the root of the tree. Branch lengths are much longer in Group B when compared to Group A. Nucleotide diversity for Group B is 0.01. Group C does not exist on the ADH-4 tree as all three accessions are monophyletic with Group A. Nucleotide diversity for Group C is zero.

The concatenated ADH-4 and GBSSI-2A data set was 3019 base pairs. These regions contained 4.2% of nucleotides as SNPs with a total of 127 SNPs as well as 16 indels. The concatenated gene tree shows three distinct groups (Figure 1.3). Group A form a highly supported monophyletic clade that consists of undesignated or cultivar designated accessions from both African and non-African countries. One wild designated accession from Northwest Africa is embedded within the Group A clade, marked with an asterisk. Branches lengths within Group A are relatively short. Nucleotide diversity for Group A is 0.0002. Group B consists of the same seven accessions as in both the GBSSI-2A and ADH-4 trees. Group B is paraphyletic diverging near the root of the tree. Branch lengths in Group B are relatively long when compared to both Groups A and C. Nucleotide diversity for Group B is 0.01. Group C has low support for being sister to Clade A and consists of the same three cultivar designated accessions as in the GBSSI-2A tree. They are in a monophyletic clade that is in between Groups A and B. Branches lengths within Group C are relatively short. Nucleotide diversity for Group C is 0.0002. Group B contained 3.4% of nucleotides as SNPs with a total of 103 SNPs as well as 13 indels. Group A contained 0.2% of nucleotides as SNPs with a total of 8 SNPs as well as 1 indel. Group C contained only a single SNP and no indels.

Discussion

Center of origin: Phylogeny

The results of our analyses are consistent with previous studies showing kenaf may have a center of origin in West Africa (Wilson and Menzel 1964), or East Africa (Murdock 1959). This study shows that the accessions designated as wild from East and South-Central Africa, Group B, diverge closer to the root of the phylogeny for both the ADH-4 and concatenated trees. Most cultivar designated, and undesignated accessions, form a monophyletic clade. This would lead to the conclusion that Group B represents the center of origin for kenaf. No samples were used from West Africa which makes it impossible to be sure where those samples would be on the phylogeny. This study is also lacking wild types from several Eastern African countries, which all could be part of the center of origin for kenaf. These findings also do not rule out the idea of a large center of origin where CWRs for kenaf cover the geographic range of several countries across West, South-Central, and East Africa.

The only wild designated accession from Northwest Africa did not come out in the clade with the rest of the wild designated accessions. All other Northwest African accessions used in this study were in the Group A clade. If the Northwest African accession is in fact a true wild type it would support the idea of Northwest Africa being the center of domestication since the wild type is more genetically closely related the cultivars. However, the alternative explanation is that this accession was in fact a feral individual that had escaped back into the wild, which is common for kenaf (BioKenaf 2007, Dempsey 1975).

As stated above, both East and South-Central African accessions diverged closer to the root of the tree. This shows those regions as the potential center of origin, but not necessarily the center of domestication. The center of domestication is shown by the clade that is sister to the clade with the cultivars, Group A. Both the ADH-4 and concatenated phylogenies show a single accession from East Africa as sister to Group A. This finding supports previous findings stating East Africa as the center of domestication (Dempsey 1975).

Center of origin: Genetic Diversity

Wild accessions are expected to show a larger amount of genetic diversity when compared to cultivar accessions (Wilson and Menzel 1964, Harlan 1971). Findings from this study support that idea by showing long branch lengths for the wild accessions. This is shown by the large number of SNPs found within Group B (103) when compared to 8 for Group A and 1 for Group C for the concatenated dataset. This is also shown with nucleotide diversity for the concatenated dataset. Group B has a nucleotide diversity of 0.01 compared to 0.0002 for Group A and 0.0002 for Group C. The accessions in Groups A and C support the idea that domestication reduces genetic variation. They also support the idea that the center of origin is where the CWRs are found (Wilson and Menzel 1964). It can be concluded that the center of origin for kenaf is somewhere in East or South-Central Africa because these areas exhibit the highest levels of genetic diversity. Northwest Africa is most likely not the center of origin as it exhibits low levels of genetic diversity. With accessions from both East and South-Central Africa showing a large amount of genetic diversity it is possible that the center of origin is a large range encompassing a large range over West, South-Central, and East Africa.

Domestication Events

A single domestication event is supported by the ADH-4 and concatenated phylogenies as they show the wild type clades diverging closer to the root of the tree and the cultivars forming a monophyletic clade (Guerra-Garcia et al. 2017). These findings support the hypothesis that most domesticated species underwent a single domestication event (Meyer 2012). However, the GBSSI-2A phylogeny shows a possibility for two domestication events as one wild clade leads to the Group C cultivars and another wild clade leads to the Group A cultivars (Qiao et al. 2016). These findings support the hypothesis that most domesticated species undergo multiple domestication events (Meyer 2012). With the current data it is not possible to definitively state if kenaf underwent a single or multiple domestication events.

Future Studies

The main shortcoming of this study is the lack of comprehensive sampling of wild accessions. USDA Germplasm accessions designated as wild are limited and not representative of the geographic range of *H. cannabinus* in Africa. A future study should focus on obtaining both wild and cultivar types from multiple countries in both west and east Africa. The wild accessions would show which geographic regions are sister to the cultivars. More cultivar accessions would show if any geographic regions with accessions designated as wild come out as sister to cultivars from the same region separate from the rest of the wild accessions. This would make it possible to identify if any accessions designated as wild were instead feral. It would be beneficial to have sampling from landraces or any other pre-domesticated plants that had some degree of artificial selection. These landraces would show which wild types were most likely to be the center of domestication and would show if kenaf underwent a single or multiple domestication events.

A focus should be made to collect in West Africa, specifically in Angola where Margaret Menzel noted a high level of morphological variation and in East Africa, specifically in Sudan and South Sudan where Dempsey states the center of domestication is located (Wilson and Menzel 1964, Demspey 1975). With those added samples it could be possible to determine if kenaf's center of origin is in fact West Africa, East Africa, or has a range that encompasses parts of both West and East Africa.

Comprehensive sampling using next-gen sequencing such as transcriptomes or including more nuclear genes to make a consensus tree would make it possible to construct phylogenies using more data. This would help to eliminate the differences often found in gene trees. A phylogeny constructed with more genetic data would have higher support and make it possible to state which wild accessions diverged closer to the root of the tree and are sister to the cultivars showing the likely center of origin for kenaf. It would also show which geographic regions are in fact wild and which are feral, as is the question with Northwest Africa.

Conclusion

This study shows that East and South-Central Africa are the most likely CWRs and therefore the likely center of origin for kenaf. They show this by diverging earlier on the phylogeny and having more genotypic variation amongst themselves. Northwest Africa has one accession designated as a wild type, but it is shown to be genetically like cultivated types and is therefore most likely a feral plant. Using all the data from this study in a concatenated tree lends support for a single domestication event. However, the GBSSI-2A gene tree shows evidence for two domestication events. While a single domestication event is the likely conclusion, it is not possible to rule out the idea of multiple domestication events.

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Appendix

Table 1.1. Plants grown from seed and used in this study.

Region	Accession #	Area of collection	Plant designation
East Africa			
	267666	Sudan	
	267667	Sudan	
	405414	Tanzania	Wild
	405443	Tanzania	Wild
	405462	Tanzania	Wild
	532998	Uganda	Cultivar
	532999	Uganda	Cultivar
	533000	Uganda	Cultivar
South-Central Africa			
	344225	Zambia	Wild
	344226	Zambia	Wild
	500702	Zambia	Wild
	500771	Zambia	
Northwest Africa			
	268079	Nigeria, Kaduna	
	268085	Nigeria, Kaduna	
	291105	Ghana	Wild
	291117	Ghana	Cultivar
	341990	Ghana	
	341992	Ghana	
	478609	Guinea	Cultivar
Other African regions			
	376260	Egypt	
	638930	South Africa	Cultivar
Outside Africa			
	189210	Indonesia, Java	Cultivar
	196988	India	Cultivar
	198673	Korea, North	Cultivar
	207896	USA, Florida	Cultivar
	207901	Cuba	
	208832	Cuba	
	248895	Poland	
	270104	Guatemala	Cultivar
	270118	Guatemala	Cultivar
	305078	Soviet Union	Cultivar
	318723	Iran	Cultivar
	323091	India	Cultivar
	324923	Russian Federation	Cultivar
	343134	France	Cultivar
	343149	France	Cultivar
	343444	Philippines, Luzon	Cultivar
	365441	Taiwan	Cultivar
	603071	USA, Texas	Cultivar
	638931	China	Cultivar
	639889	USA, Mississippi	Cultivar
	670458	USA, Florida	Cultivar

Table 1.2. Primer sequences used to amplify both gene regions. The number in the primer name refers to the exon it is in and the F = forward and the R = reverse. The X and * refer to the version of that primer used. All annealing temperature are in °C.

GBSSI-2A	Primer	5' - 3'	Annealing Temperature
	X2F	TGACNGTGTCTCCTCGCTATGAT	60
	4F	ATCAAYTGCGRTTYAGCTTG	53
	7R	ATGAARTCRAATGAACTCTTGAA	53
	9R *	CCAATGAACCCAATCAAGGGAGC	60
ADH-4			
	X2F	CTGATGTCTACTGGGAGTG	59
	X4F	CGTGACCGACGTGAAACCG	57
	X8R	ATCATGGACGCATTCAAAAGCC	59

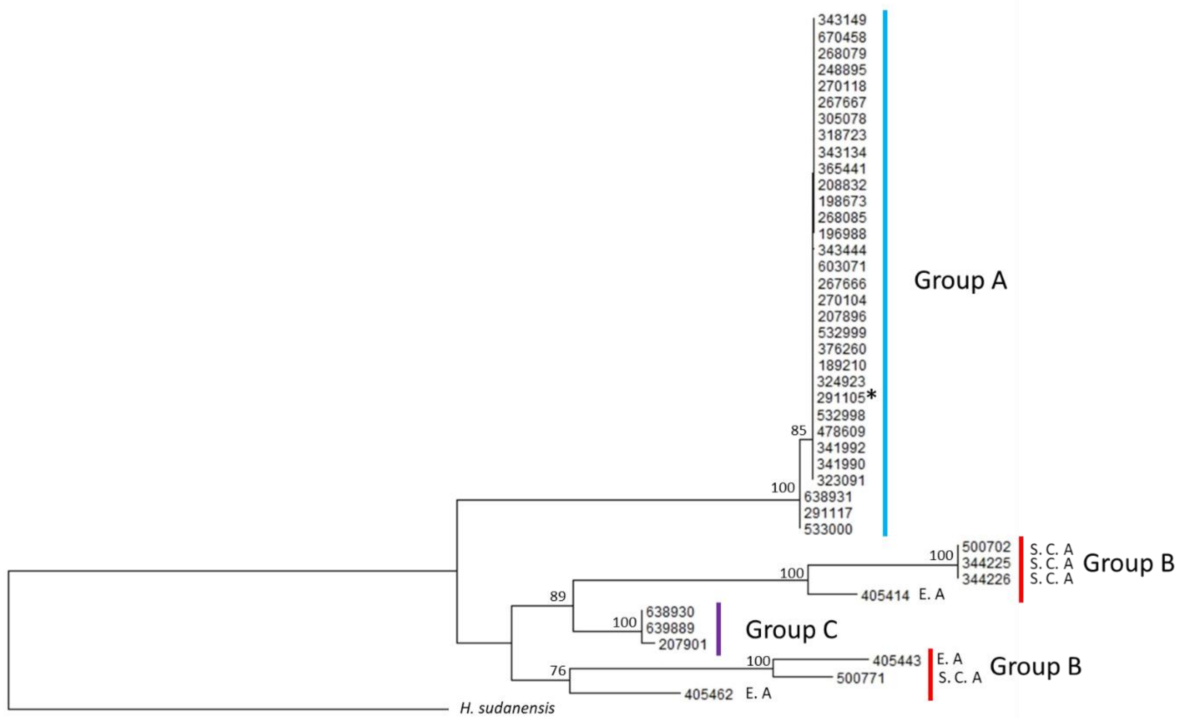

Figure 1.1. Maximum likelihood analysis of the GBSSI-2A gene region.

Group A is a monophyletic clade of accessions undesignated or designated as cultivars from African and non-African countries. Group B is a paraphyletic group that consists of wild designated and undesignated accessions. Group C forms a monophyletic clade and consists of accessions designated as cultivars. The asterisk marks an accession designated as wild from Northwest Africa. All accessions in Group B are labeled as E. A for East Africa or S. C. A for South-Central Africa.

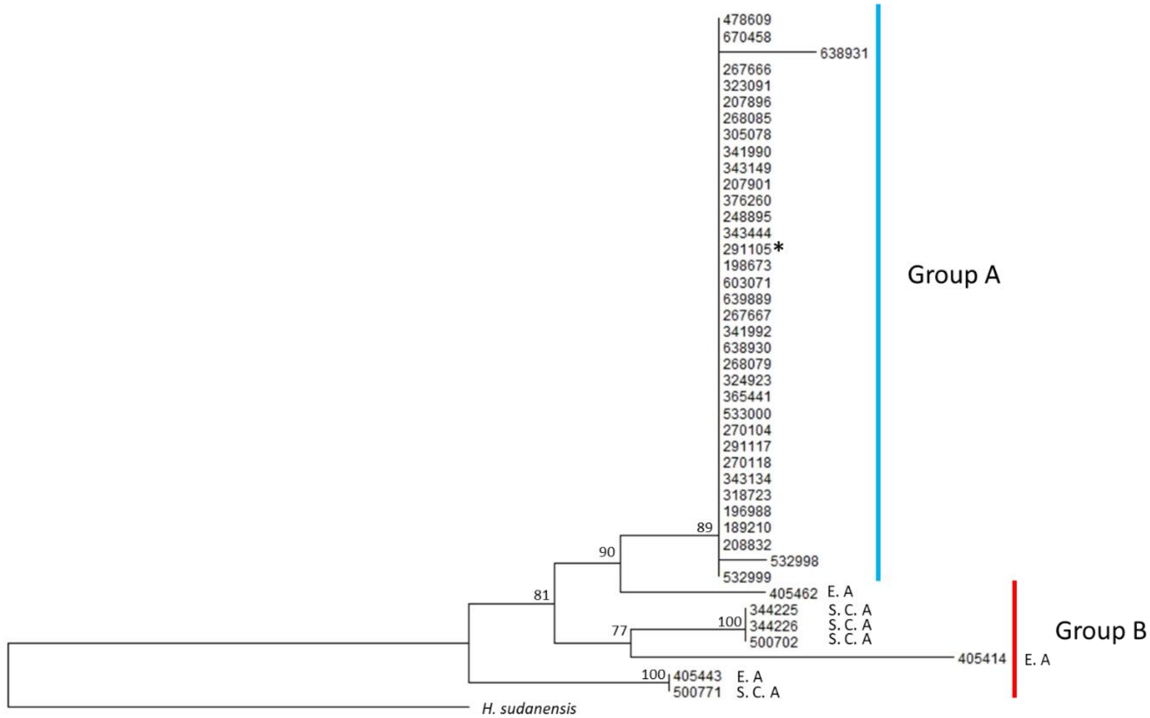

Figure 1.2. Maximum likelihood analysis of the ADH-4 gene region.

Group A is a monophyletic clade of accessions undesignated or designated as cultivars from African and non-African countries. Group B is a paraphyletic group that consists of wild designated and undesignated accessions. The asterisk marks an accession designated as wild from Northwest Africa. All accessions in Group B are labeled as E. A for East Africa or S. C. A for South-Central Africa.

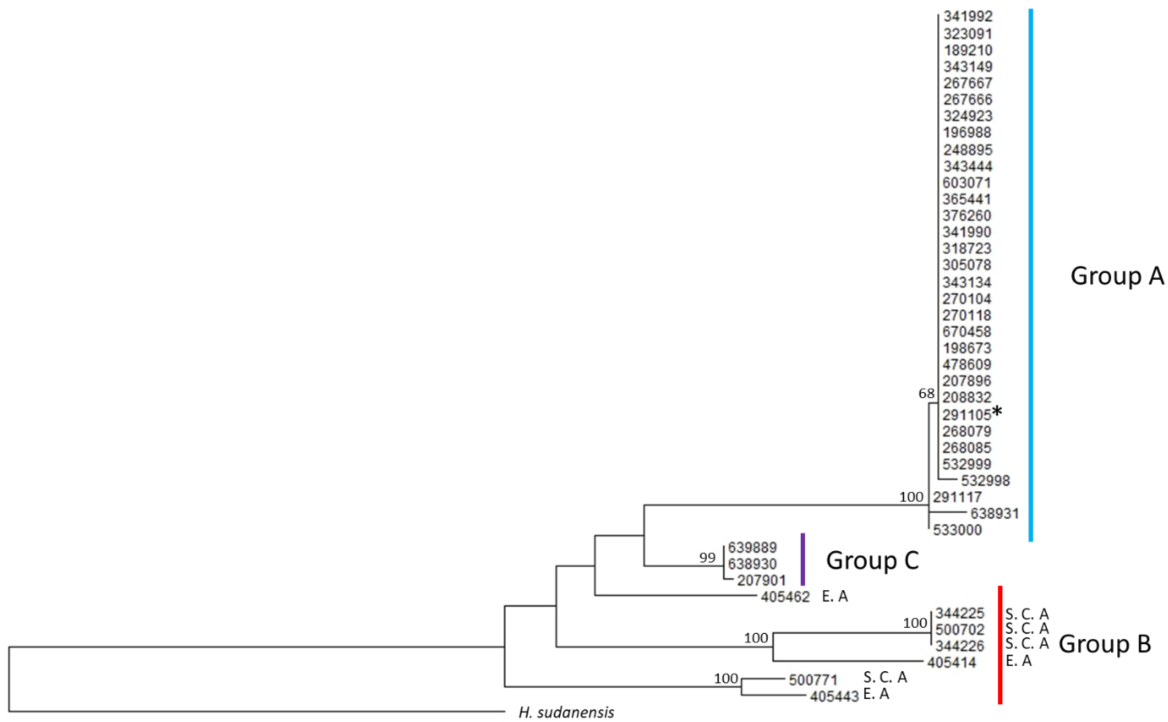

Figure 1.3. Maximum likelihood analysis of concatenated ADH-4 and GBSSI-2A gene regions. Group A is a monophyletic clade of accessions undesignated or designated as cultivars from African and non-African countries. Group B is a paraphyletic group that consists of wild designated and undesignated accessions. Group C forms a monophyletic clade and consist of accessions designated as cultivars. The asterisk marks an accession designated as wild from Northwest Africa. All accessions in Group B are labeled as E. A for East Africa or S. C. A for South-Central Africa.

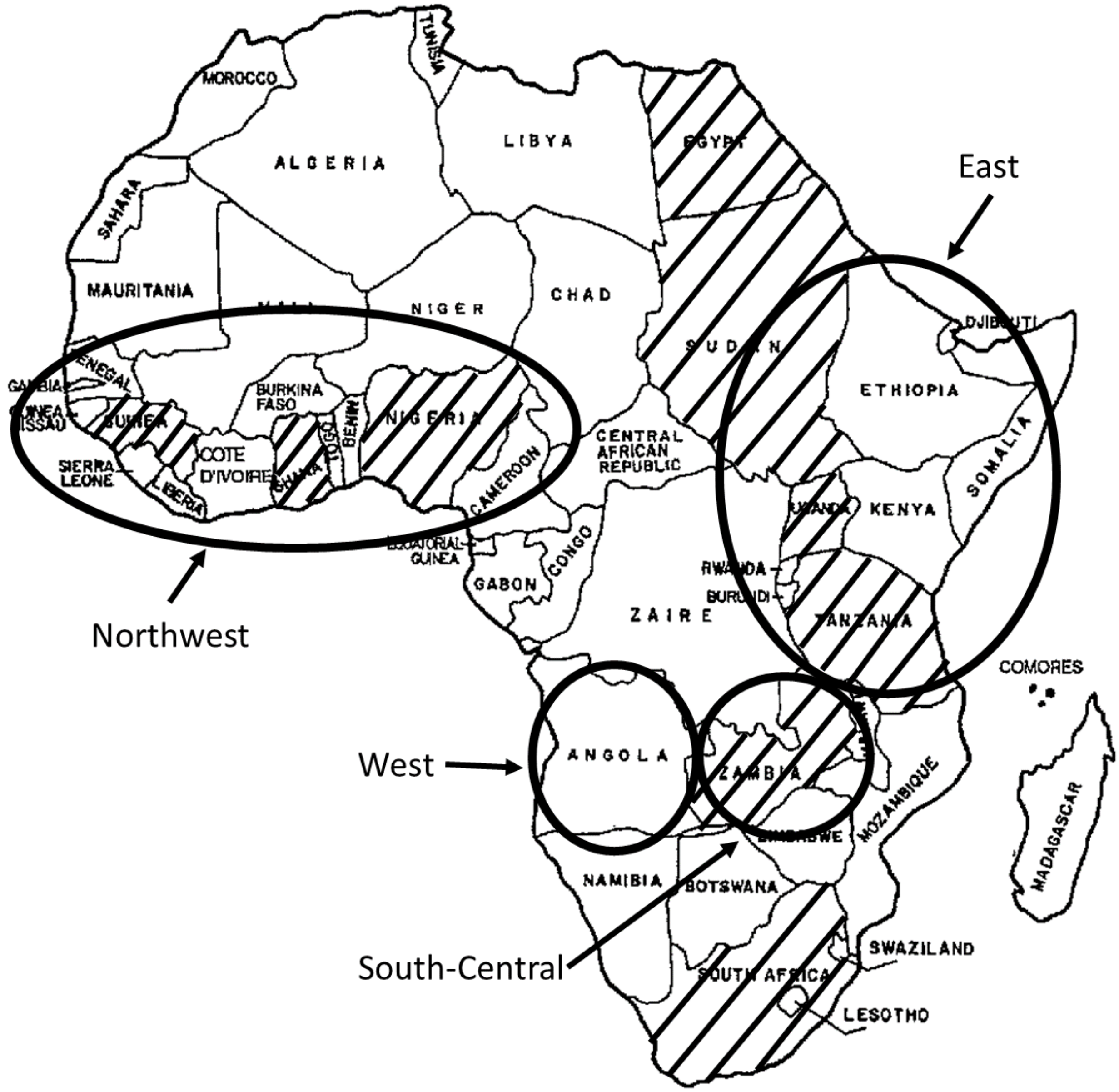

Figure 1.4. A map of Africa with the nine countries included in this study marked by dashes. The four regions hypothesized as the potential center of origin, East, South-Central, West, and Northwest Africa, are circled.

Chapter Two

Student perception versus reality:

How optional supplemental videos impact student confidence and skills

Abstract

Instructors often assign optional supplemental material to their students to reinforce concepts and skills from their curriculum. Many instructors view this material as a useful way to engage students outside of the classroom and help them learn. However, it is unclear how the use of this material effects students. This study analyzes the effects of student viewing of optional supplemental videos on confidence in scientific skills, perception of future success, perception of instructor, and academic performance. There were significant differences between students who watched the supplemental videos and those who did not watch the videos on an end of semester common assessment. Students who watched the supplemental videos found the videos useful as a study tool and performed significantly better on a common performance assessment than students who did not watch the videos. However, the students who watched the videos also self-reported lower levels of confidence, perception of future ability, and perception of their instructor. This suggests that the videos may have led students to question their knowledge compared to students who didn't watch the videos, despite their positive impact.

Introduction

There is an ever-increasing volume of knowledge within the disciplinary area of Biology, and it is often difficult for instructors to cover the increased amount of material in their classes (Gregory et al. 2011). Some instructors compensate by increasing the speed and amount of material; in these cases, students either fall behind or desire more practice, review, and feedback (Brittain et al. 2006). A growing trend in introductory courses is to offer podcasts of the lectures along with optional online material. Research on student perceptions of these supplemental materials found that podcasts and other optional online material were perceived as useful and beneficial towards understanding class material (Aza et al. 2015, Middleton 2016, Luttenburger et al. 2018, Guertin et al. 2007, Cardall et al. 2008).

Some instructors have started requiring students to use online resources. Students who were required to use online material gave it a higher score for usefulness when compared to students given the same material as optional (Garland and Noyes 2004, Johnson and Howell 2005). When students were required to use some of the online material, they were also more likely to use other optional online material than students who were provided optional access to online material (Johnson and

Howell 2005). This research shows both a need for instructional materials outside of the classroom and an understanding of how students engage with course material on their own time.

Although students view podcasts and other online material as a flexible, engaging, and re-playable medium that provides additional instruction outside of the classroom (Middleton 2016), however, students do not always engage with optional supplemental material (Guertin et al. 2007, Cardalle et al. 2008, Orton-Johnson 2009). Some researchers have contended that online learning material works best as a standalone class and that traditional class lectures are not designed properly to take advantage of a blended teaching environment with these materials (Oliver 1999). Even in blended classrooms there are students who trust the conventional way of learning through lecture and texts and do not use the optional material (Orton-Johnson 2009). Instructors who choose to use supplemental information must design their course to incorporate the optional online material as part of the class.

The format of online materials that students prefer is important to student engagement. Although it is not clear whether audio podcasts are more beneficial than video podcasts, there is some evidence that audio podcasts are more beneficial to students (Brittain et al. 2006). Others show that when using video material, the type of video is important to engage students (Brame 2016, Guo et al. 2014). Shorter informal videos are more effective at engaging students than high-quality pre-recorded lecture (Guo et al. 2014). More research is needed on how the different types of material impact students in classes.

Evidence also indicates that only some of the students in a class engage with the material (Guertin et al. 2007, Cardalle et al. 2008, Orton-Johnson 2009, Luttenburger et al. 2018). This could be due to the type of material or because of instructor effect. Instructor interactions with students can increase student participation and motivation towards the class (Chin 2006). Student-faculty relationship has been shown to positively predict student grades and willingness to engage with course material (Micari and Pazos 2012). Studies investigating why students do not engage with optional online material show that students often are not aware of the material or do not know how to access it (Guertin et al. 2007), but there are also indications that they do not engage with the material due to lack of instructor support towards the use of the material or student apathy (Garland and Noyes 2004). One area that has not been studied is if instructor effect has any consequence on students' engagement with optional online material; this may be key to increasing student use of the material.

Another area of research is which students gain from engaging in online materials. A study analyzing how students engage with video podcasts showed that these students put more time into learning and studying, through note-taking, summary generation, and rehearsing with the podcasts

(Luttenburger 2018). However, there have also been conflicting results. Some studies showed no significant academic gains compared to students who did not use the optional material (Azab et al. 2016), while other studies showed it did improve student academic performance (McDaniel et al. 2007, Johnson 2006). However, in cases where academic improvement was observed it was not possible to rule out other factors such as implementing active learning practices in the classroom or a bias toward higher-achieving students being more likely to use the materials (McDaniel et al. 2007, Johnson 2016). One clear area where optional online material is not effective is for students who do not attend lecture and rely solely on the optional online material. These students saw lower academic performance (Inglis et al. 2011). Some areas where optional online material did show academic improvements were with students who missed class and had to make up the material, and with English as a second language students (Grabe and Christoferson 2008, Rahimi and Soleymani 2015). More studies are needed to determine exactly if and how optional online materials improve student academic performance.

Regardless of any academic benefit from the use of optional materials, these materials may be important in boosting student confidence in the form of self-efficacy. Self-efficacy refers to an individual's confidence that he or she can perform a specific task or accomplish a specific goal (Bandura, 1997). Higher levels of self-efficacy have led students to work harder on difficult tasks and to be more likely to engage with course material (Schraw et al. 2006, Eccles and Wigfield 2002). Confidence has been related to a higher college science grade point average for some students (Glynn 2011, Lent et al. 1986). Little research has looked at the link between supplemental material and self-efficacy, but instructor effect has been shown to positively correlate with student confidence, as students who have a positive perception of their instructor exhibit greater confidence (Micari and Pazos 2012). Studies are needed to better understand the effects of supplemental materials on student confidence while also accounting for instructor effects.

The purpose of this study is to better understand the effects of using optional supplemental videos on student confidence and academic performance. This will be done by addressing several research questions. First, will watching the supplemental videos improve student academic performance on a common assessment? Second, will watching the supplemental videos improve student short-term and long-term confidence in their biology skills? Third, will watching the supplemental videos improve student perception of their instructors? My hypothesis is that watching the supplemental videos will improve student confidence and academic performance. An alternative hypothesis is that any significant differences will be due to instructor effect and not engagement with the supplemental videos.

Methods

Context and Participation

The potential participants of this study were undergraduate students enrolled in one of four first-semester organismal and ecological biology lecture courses (N ~ 220 each) during the fall 2018 semester at a large public research University in the South. This population comprised about 866 students. Around 75% of the students who enrolled in this class were first-year students, while the rest were second-year students or older.

The organismal and ecological biology class is three credit hours; students meet in the large lecture format for two of those hours, and then in small section Biological Literacy discussion for the third hour. This study was performed solely within the context of the Biological Literacy (BioLit) sections. The BioLit sections are taught by graduate teaching assistants (GTA). For each large lecture class, there are 9 discussion sections, and one GTA teaches three of these.

The overall purpose of the BioLit discussions is to develop student proficiency in reading biological literature, including identifying hypotheses, diagraming methods, interpreting figures, and drawing conclusions. The BioLit class is separated into three modules. Module one focuses on identifying research questions of a study, understanding research methods, and interpreting graphs and tables, and is assessed via a GTA-written quiz. Module two focuses on synthesizing scientific results, identifying the take-home message of a single paper, and understanding systems interaction models, and is assessed via a second GTA-written quiz. The final module is a poster presentation where students work in pairs to create a scientific poster using a new paper and to identify components of a successful poster presentation. To enact the curriculum, GTAs are provided template PowerPoints and structured worksheets that all students must complete in small groups during the 50-minute class period. To prepare for implementation, GTAs attend a 1.5-hour weekly preparation meeting where the curricula are explained and discussed.

A total of nine GTAs were a part of this study; they will be referred to as “instructors” throughout the rest of this paper. The first author randomly selected five instructors as those who would give students access to the optional supplemental videos; the other four instructors were not provided these videos. In total, 15 sections of students received the videos and 12 sections of student did not. This totaled 364 students in the potential treatment group and 288 students in the comparison group (without videos).

The first author made seven videos in the form of voiced-over PowerPoints which focused on different BioLit learning objectives that students commonly struggled on. These included hypothesis writing, popular science versus peer reviewed papers, methods diagrams, figure interpretations, P-values and significance, manipulative versus observational experiments, and syntheses and take-home messages. Each video was about ten minutes in length and focused on modeling each of the covered concepts and skills. Four videos were made available to students before the first quiz and another three were made available before the second quiz, based on how the content matched each module.

Data Collection

Students in the course take an end of semester programmatic evaluation that asks about their perception of the BioLit course. For this semester, the first author created and added measures of four constructs to this evaluation: confidence in particular BioLit skills, perception of future ability, instructor effectiveness, and BioLit knowledge. The quiz 1 and quiz 2 given during the semester in the BioLit classes were not used to assess student academic performance because they were created by individual instructors and were not standardized. The end of semester common assessment was the same for all students but was not a comprehensive examination of all BioLit concepts and skills. Instead, the questions matched most of the learning objectives covered in the supplemental videos.

The first author created all survey and assessment questions and had two biology education researchers review them before implementation. Confidence questions were meant to measure a student's short-term confidence on their BioLit skill proficiency. They did this by asking, 'How much did BioLit 150 contribute to your ability to…", and then had one question for each of ten learning objectives and skills used in the videos. Students could choose from a five-point scale including not at all, a little, somewhat, very, and extremely. Student perception of future ability questions were meant to measure a student's long-term confidence in their success by focusing on classes after this BioLit class. The questions asked students to rate their confidence in their ability to succeed in: the next BioLit course, BioLit 160 (cellular lecture), and in future biology courses. Students could choose from a five-point scale including not at all confident, slightly confident, somewhat confident, very confident, and extremely confident. Questions to measure student perception of their instructors asked, 'mark your degree of agreement with the following statements.' Five questions asked if your BioLit instructor is confident, knowledgeable, fair, an effective teacher, and would you take another class taught by your instructor. Students could choose on a four-point scale including strongly disagree, disagree, agree, strongly agree.

All scales were transformed into a numeric scale of 1-5 or 1-4. The average of those numbers for each construct (confidence in skills, future ability, and instructor perception) were used as the measure for each student.

The common assessment questions were all multiple choice with four choices and were mainly scenario-based. This format was chosen because it is the format used on the quizzes as well. The first author has taught the BioLit course multiple times and understood how these questions are typically written; the questions were also vetted by the course coordinator. Questions were scored as either correct or incorrect (1 or 0) and the average of the correct items was used as the score for each student. These were averaged by instructor as well.

Finally, there were questions after each of the two quizzes in which students were asked whether they watched the videos and if they found them useful in preparing for the quiz (for students who had access to the videos). Students chose either yes, the videos were useful or no, they were not useful

Data Analysis

Only students who completed the two post-quiz surveys and the end of semester evaluation were used in the study. Data from the two post-quiz surveys and the end of semester evaluation were paired together by student name by a third-party person. Once matched together, the data were labeled for each instructor, anonymized, and passed onto the researcher. Two questions were used from the post-quiz surveys; one was the self-reported video watching, and the other was if the videos were useful when studying for the quiz. All other question used in the analysis came from the end of semester evaluation.

Students were placed into two groups based on their post-quiz surveys and treatment groups. The first group of students had no access to the supplemental videos. The second group of students had access to the videos and responded that they watched the supplemental videos for either quiz 1 or quiz 2 or both quizzes. Students who responded that they did not watch the supplemental videos while having access to them were removed from the study. This was done to ensure a strict cutoff between the groups of students who had access to and watched the videos and those who did not have access to the videos.

The two student groups were called either yes (students who self-reported watching the videos) or no access (students that had no access to the videos). These students were compared based on their scores on the four constructs measured on the end of semester survey: confidence, future ability, instructor effectiveness, and assessment. These analyses were done using a t-test in R (R 2018). Each student was also sorted by instructor. Each of the nine instructors was compared for the four constructs assessed on the end of semester evaluation. This was done to determine if instructor effect had a greater effect than the videos. These comparisons were done using an ANOVA and TukeyHSD post hoc test in R (R 2018).

Students who watched the videos were also asked on the post-quiz surveys if they found the videos useful when studying for the quiz. Only students who watched the videos and students who answered that question were counted to determine how many students found the videos helpful. Analysis was done by calculating a percent yes and percent no for each quiz.

All procedures used in this study were approved by the University's institutional review board.

Results

Of the students who completed all surveys and who had access to the videos (N = 187), 73% (N = 137) self-reported watching at least some videos and were placed in the yes group; 50 students choose not to watch the videos. Another 117 students were placed in the no access group, meaning they had no access to the optional supplemental videos and therefore did not watch them (although we have no way to verify this). The number of students in both the yes and no access groups for each instructor can be found in Table 2.1.

Students who had no access to the supplemental videos had significantly higher self-reported levels of future ability, confidence, and instructor perception (Figures 2.1, 2.2, and 2.3). Students who had access and watched the videos performed significantly better on the end of semester common assessment (Figure 2.4). Average values for all four constructs are shown in Table 2.2.

Student confidence differences among instructors showed no significant differences among the instructors (Figure 2.5). Student future ability differences among instructors showed one instructor who was significantly higher than two instructors (Figure 2.6). Student instructor perception differences among instructors showed three instructors being significantly lower than at least one instructor (Figure 2.7). Student assessment differences among instructors showed one instructor was significantly greater than six other instructors while one instructor was significantly lower than two instructors (Figure 2.8).

Any significant differences, degrees of freedom, and F-values are indicated in figures 2.5, 2.6, 2.7 and 2.8.

For the students who watched the videos in preparation for quiz 1, 60 students said yes the videos were useful in preparing for the quiz and 2 said no. For quiz 2, 117 of the students who watched the videos said they were useful and 3 said no. Thus, over 97% of students found the supplemental videos useful when studying for the quizzes.

Discussion

Consistent with my hypothesis, watching optional supplemental videos did cause an increase in student performance on a common assessment at the end of the semester (Figure 2.4). However, contrary to my hypothesis, it did not increase their confidence. Students who watched the optional supplemental videos showed significantly lower values for confidence, ability towards future biology courses, and instructor perception compared to those who did not watch the videos (Figures 2.1, 2.2, 2.3).

Instructor effect did not account for the significant differences observed between the yes and no access groups. Instructors had no significant difference between each other for student confidence and only a single significant difference for future ability (Figures 2.5 and 2.6). Some instructors had significant differences for instructor perception and assessment (Figures 2.7 and 2.8). These differences are not enough to assume they effected the significant differences found between the yes and no access groups for these constructs. The alternate hypothesis that any significant effects would be due to instructor effect is not supported and any significant effects are due to engagement with the supplemental videos.

It is surprising that watching the videos did not improve student confidence in BioLit skills or confidence in future ability. This is despite students reporting that they found the videos useful in studying for the quizzes. One possible explanation is that students who watched the videos were more aware of what they did not know pertaining to each learning objective. Watching the videos right before taking the quizzes could have clarified which of the concepts and skills that they did not fully understand. The interesting thing is that this uncertainty carried through to the end of the semester, suggesting that although the videos were useful in quiz preparation, the students had no way to know whether their learning was enhanced and continued to doubt their understanding.

Another possible explanation is that there was a time delay between when students watched the videos and when they reported their confidence. The students watched the videos the week before each quiz and self-reported their confidence levels at the end of the semester. That is about a one-month gap between the second quiz and filling out the end of semester evaluation. Perhaps by this time any gains in confidence from watching the videos had decreased. It is possible that these students were more aware of all the concepts and skills that they had forgotten, and that lowered their confidence. It may also have been that the common assessment or finishing the poster assignment (which occurred at about the same time) reminded them of the concepts or skills that they had forgotten.

In prior studies, students that are underperformers on a task have been shown to exhibit high levels of confidence. One widely accepted explanation for this is the Dunning-Kruger effect. This effect is where students that are unskilled are not aware of their own inadequecies leading them to have overstated self-assessment (Kruger and Dunning 1999). The Dunning-Kruger effects also shows that teaching a concept or skill to someone who has little knowledge of that skill will act to lower their self-assessment towards that concept or skill. It is not until that individual reaches higher levels of understanding that their confidence starts to increase. This effect could explain why students that performed lower on a common assessment had higher levels of confidence while students that performed better on a common assessment has lower levels of confidence. Student performing worse on the common assessment had a limited knowledge of those concepts and skills and were unable to properly self-assess their abilities. Student performing better on the common assessment were more aware of the concepts and skills and that made them have lower self-assessments.

Even if student confidence was not raised by watching the videos, it should be noted that the students liked the videos. Using data from both post-quiz surveys showed that over 97% of students said the videos were useful when studying for the quizzes, which aligns with previous findings (Aza et al. 2015, Middleton 2016, Luttenburger et al. 2018, Guertin et al. 2007, Cardall et al. 2008). Previous studies also showed that students do not always engage with optional material (Guertin et al. 2007, Cardalle et al. 2008, Orton-Johnson 2009), but this study found that 73% of students who had access to the videos ended up watching them. Many of the instructors reported that several students even asked for more videos. This shows that students actively sought out the videos when studying and viewed them as a useful way to prepare for the quizzes.

The decrease in instructor perception can be explained by students liking the videos. Students asked for more supplemental videos and asked their instructors for more of them. Students also wanted their instructors to personally make the videos, so they were tailored to their instructor's teaching methods. The videos would have included different style questions than what their instructor used on their quizzes. If students felt their instructor had not done anything to help them prepare for the quizzes and instead used videos made by somebody else, then it could have lowered their perception of their instructor. Also, it is possible that making students more aware of the concepts through engagement with the supplemental videos resulted in lowered confidence as explained by the Dunning-Kruger effect. If students were aware of their lowered confidence, they could have blamed it on the instructor for not helping them reach an expert level of knowledge towards that skill or concept.

The common assessment showed that students who watched the supplemental videos performed significantly better on a skills test than students who did not watch the videos. This goes against some previous findings (Azab et al. 2016, Inglis et al. 2011) and backs up others (McDaniel et al. 2007, Johnson 2006). The assessment questions in this study were based off of short scenarios written in a manner consistent with the quizzes. However, these questions were multiple choice while the quizzes were short answer questions. This means that students could not receive partial credit as they could on the quizzes. Even with those differences in mind, we feel that the assessment acted as a good gauge of student knowledge because of its focus on the specific learning objectives for the BioLit course. We conclude that watching the videos clarified student understand of those concepts and skills. Not only did they learn, but they also retained that knowledge over the length of a semester.

The fact that the instructor effects were mostly non-existent is good news for a course taught by instructors with high turnover. Previous studies have shown that instructor effect can be crucial in having students engage with and learn from supplemental material (Micari and Pazos 2012, Guertin et al. 2007, Garland and Noyes 2004). In this study it appears that the videos seemed to work regardless of instructor. It also showed that any instructor can implement supplemental videos and can most likely expect an increase in student knowledge and understanding. It is still possible that individual instructors have different effects on student confidence and academic performance, but with an established curriculum, using optional supplemental videos appears to uniformly add value for the students in that class.

This study has certain limitations. The data for confidence, future ability, and instructor perception were all self-reported and the measures were created by the first author. Although there were apparent differential learning gains between the two groups, it is not possible to know whether the differences will be maintained over time. It would also be useful to give students assessments after a longer time, such as one year later, to monitor if any learning gains are retained by the students watching the supplemental videos. This study was completed during one semester using nine instructors. Increasing the sampling to include multiple semesters and more instructors would lead to more robust results.

It would be beneficial to conduct a future study comparing instructors with experience teaching this course and instructors who have never taught this class. With this type of class being focused around group work, first time instructors often struggle with how best to manage the classroom while focusing on learning objectives. Unfortunately, the group of nine instructors used did not offer a good comparison of experienced and non-experienced instructors, since many had taught the course previously.

This study showed that student engagement with optional supplemental videos specific to class learning objectives significantly increased academic performance on a common assessment of those learning objectives. However, their perception of the gains did not match the reality of this learning. Instructors need to communicate to students the learning value of these videos to counteract any potential loss of confidence that they might create. This communication of potential impact may be critical to student commitment to and learning from optional videos such as these.

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Appendix

Table 2.1: The number of students who completed both quiz surveys and the end of semester evaluation used in this study for each instructor.

Group	Instructor	Students
Yes	1	25
	2	29
	3	25
	4	34
	5	24
No access	6	36
	7	26
	8	25
	9	30

Table 2.2: Average values for each of the four constructs are given for both the yes (students watched the videos) and no access (students did not watch the videos) groups. Future ability and confidence had a range of 1-5. Instructor perception had a range of 1-4. Assessment was scored with a range of 0-1.

Group	Future Ability	Confidence	Instructor Perception	Assessment
Yes	3.5	4.0	3.4	0.66
No access	3.9	4.3	3.7	0.57

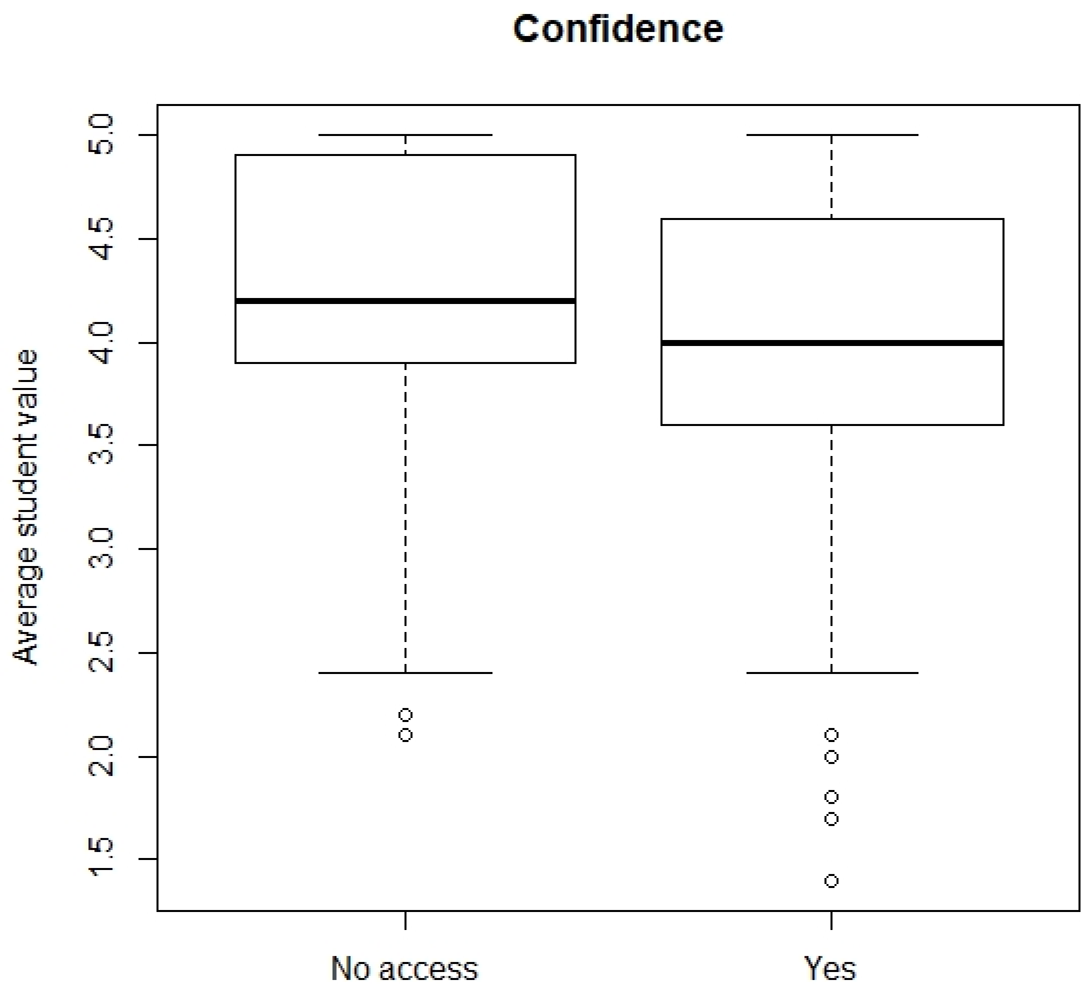

Figure 2.1: Students with no access to the optional supplemental videos rated themselves significantly higher in their confidence to perform skills relevant to the class they were currently taking, when compared to students who watched the videos. N = 117 no access students and N = 137 yes students. P = 0.001.

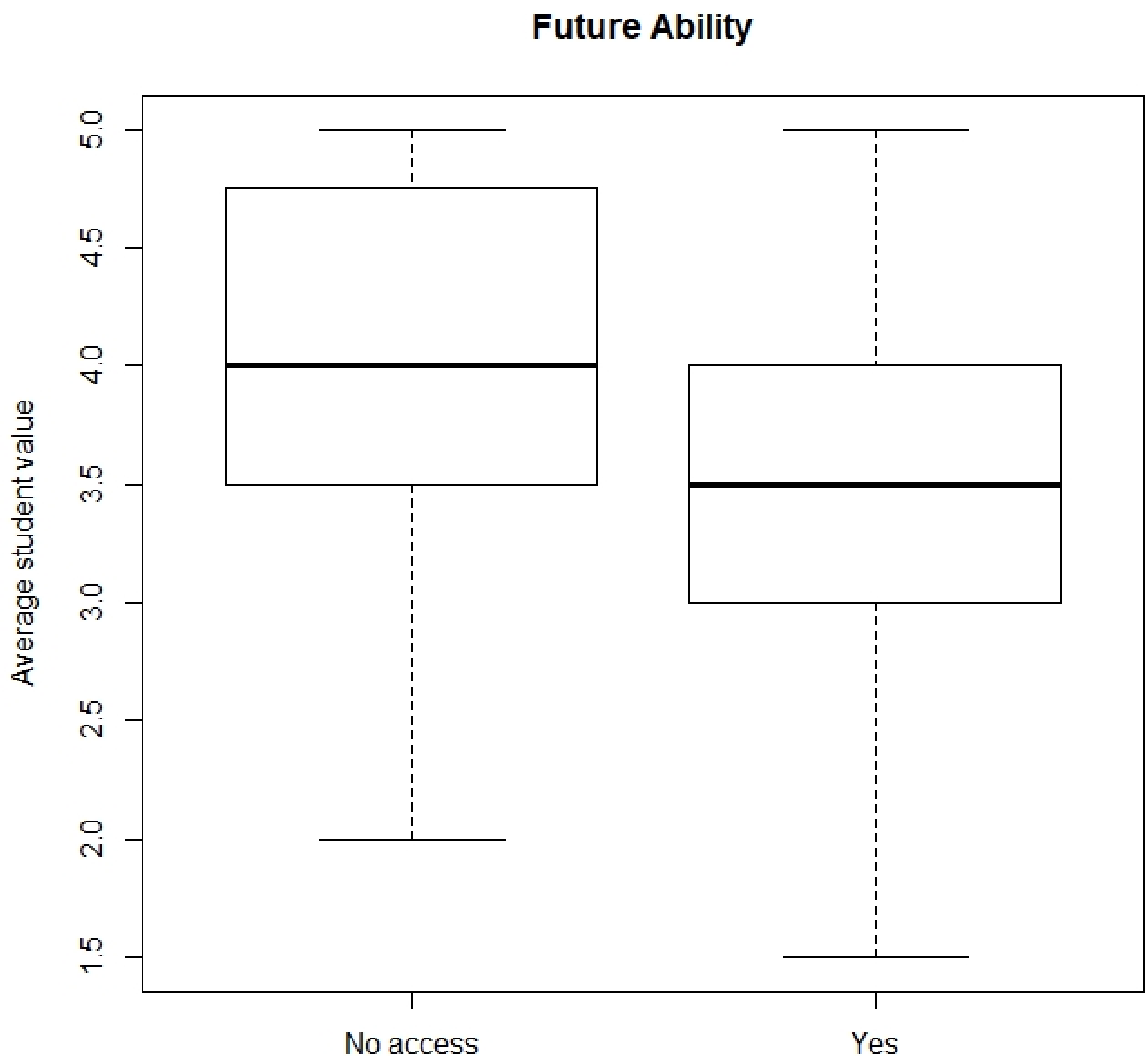

Figure 2.2. Students who had no access to the optional supplemental videos rated themselves significantly higher in their ability to perform well in future biology courses than students who watched the videos. N = 117 no access students and N = 137 yes students. P = 0.0002.

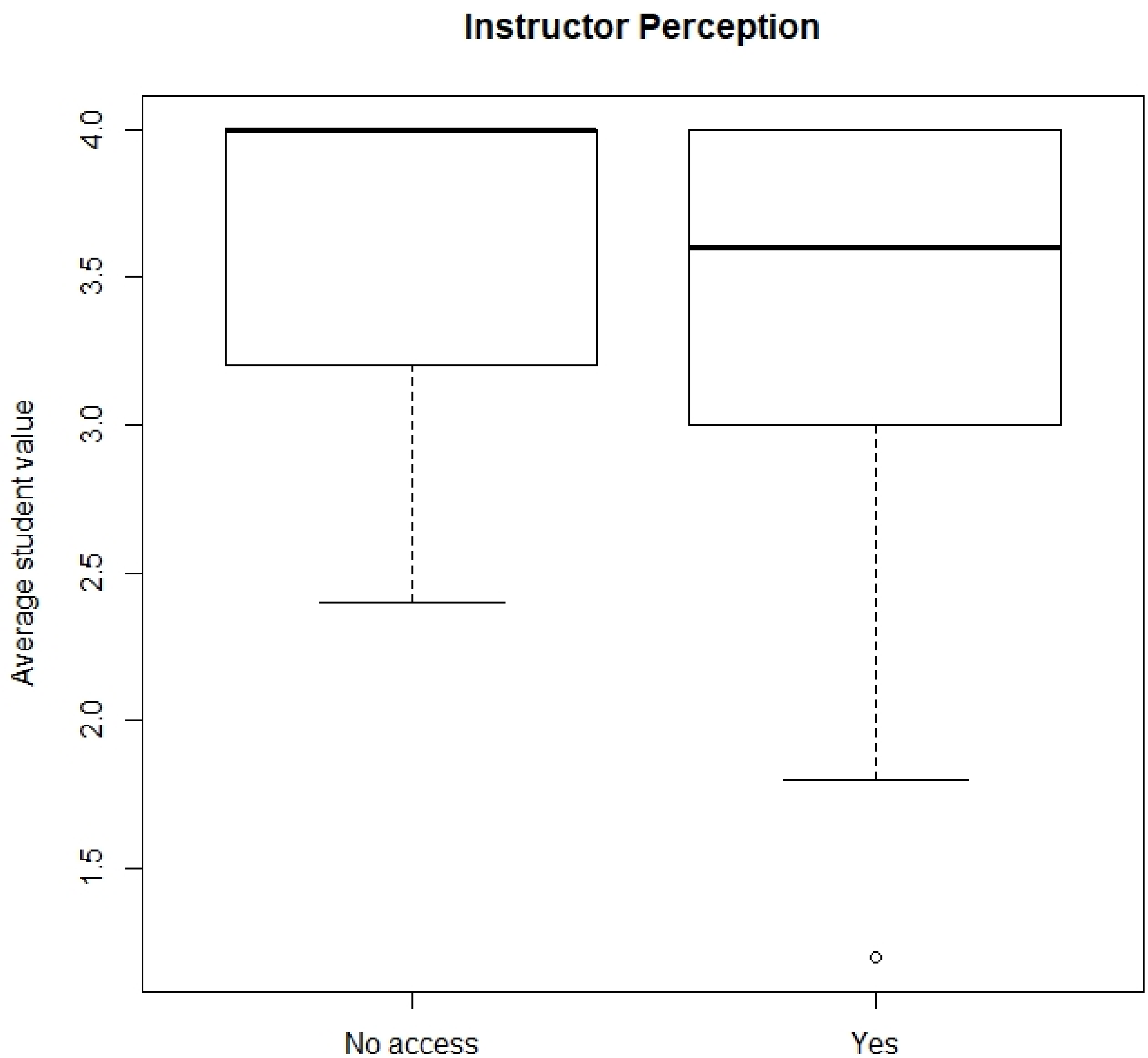

Figure 2.3. Students who had no access to the optional supplemental videos had a significantly higher perception of their BioLit instructors compared to students who watched the videos. N = 117 no access students and N = 137 yes students. P < 0.001.

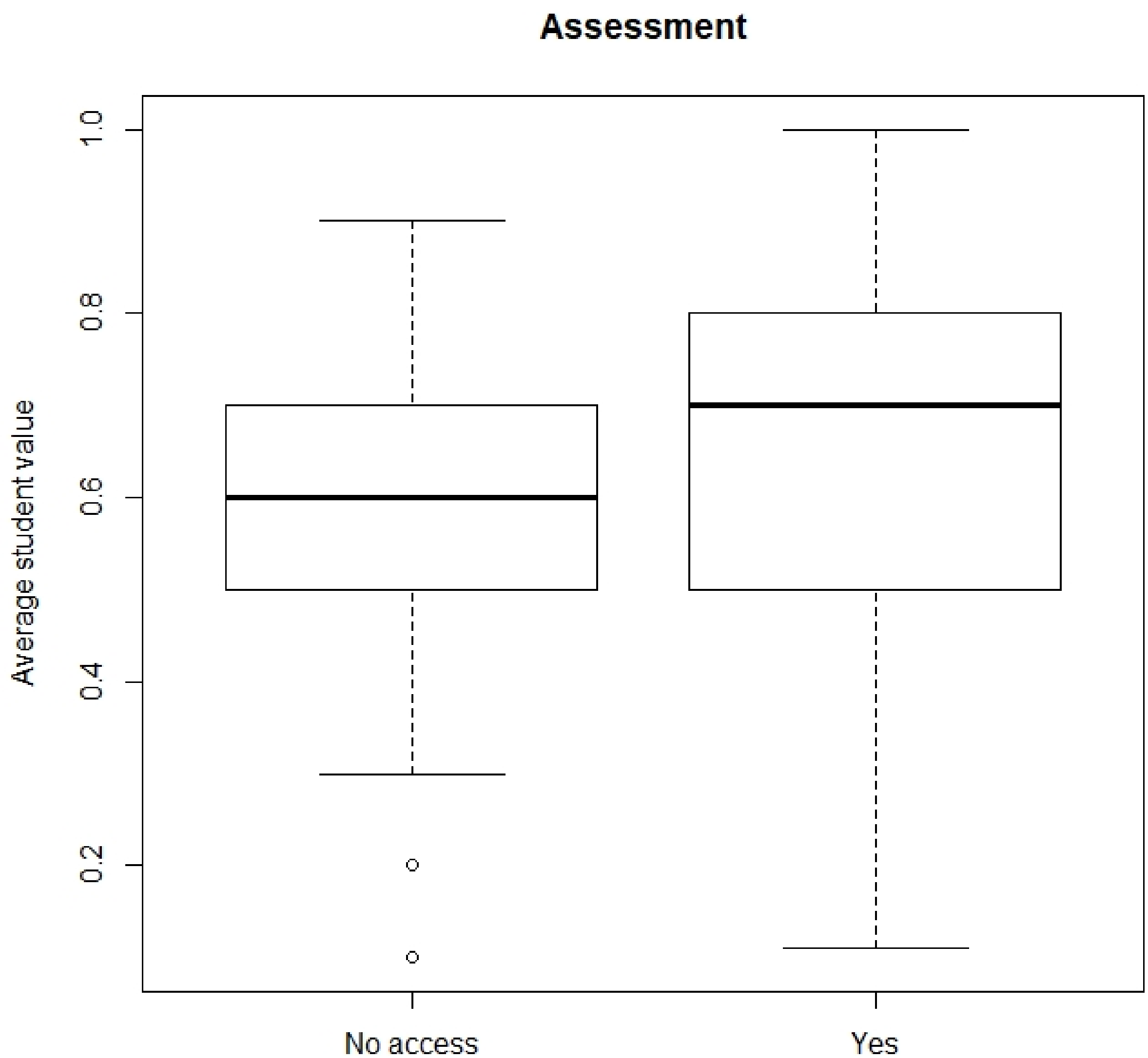

Figure 2.4. Students who watched the optional supplemental videos had a significantly higher average on a common end-of-semester assessment of BioLit skills when compared to students who had no access to the videos. N = 117 no access students and N = 137 yes students. P = 0.0001.

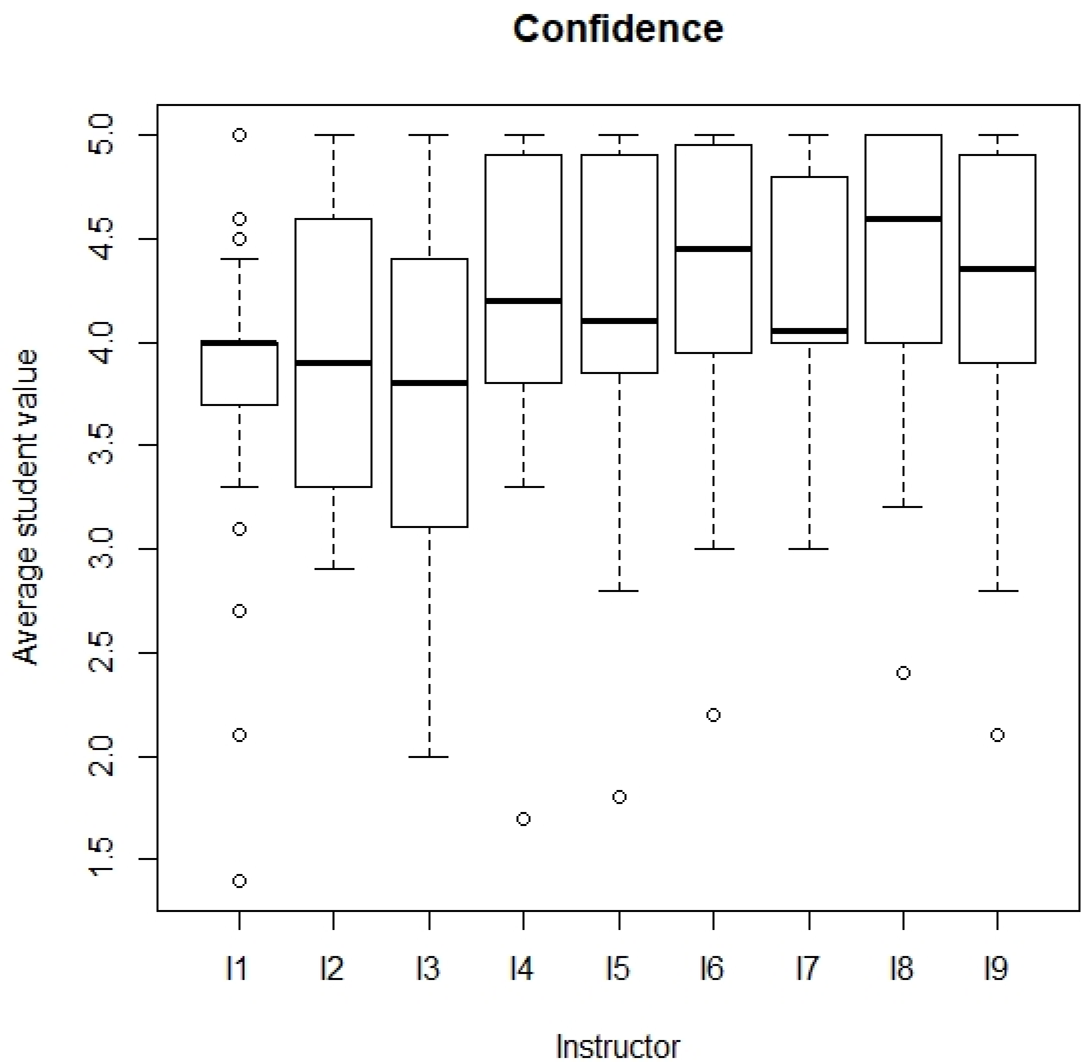

Figure 2.5. Instructors 1-5 consisted entirely of students who watched the supplemental videos, while instructors 6-9 had students with no access to the supplemental videos. DF = 8, F-value = 2.421. No significant differences were found among the instructors.

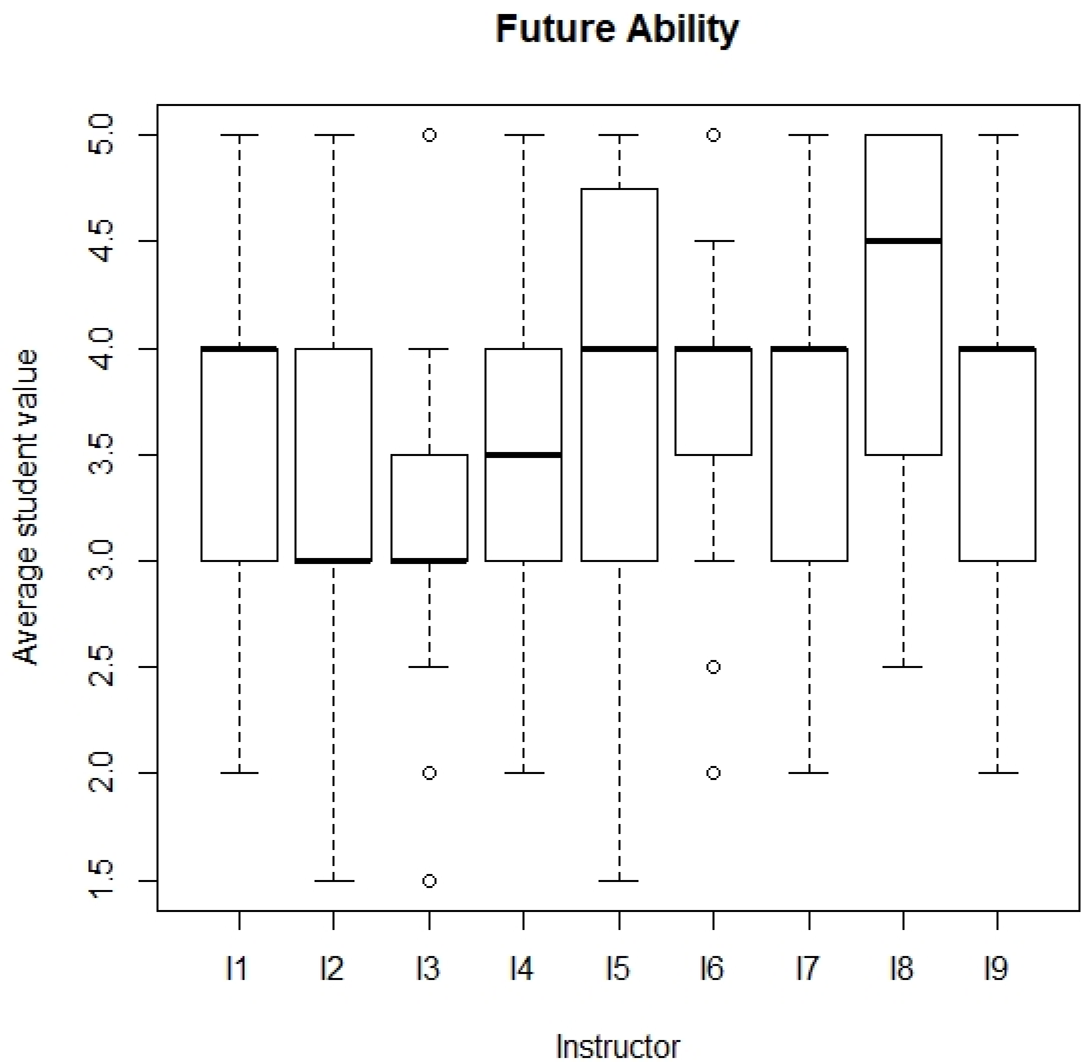

Figure 2.6. Instructors 1-5 consisted entirely of students who watched the supplemental videos while instructors 6-9 had students with no access to the supplemental videos. DF = 8, F-value = 3.37. Instructor 8 had a significantly higher average student value than instructors 2 (P = 0.007) and 3 (P = 0.0009).

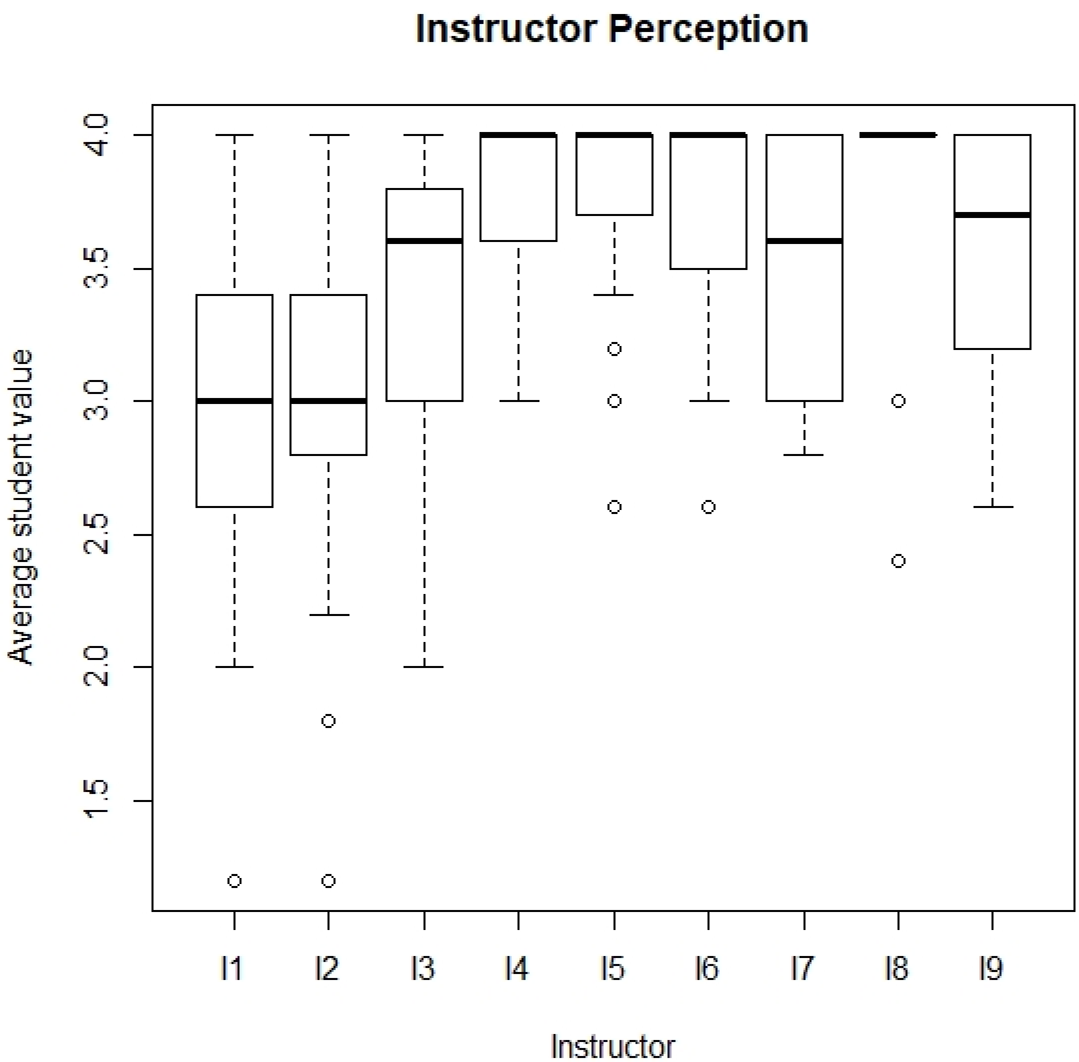

Figure 2.7. Instructors 1-5 consisted entirely of students who watched the supplemental videos while instructors 6-9 had students with no access to the supplemental videos. DF = 8, F-value = 11.55. Instructor 1 had a significantly lower average than instructors 4 (P = 0.0000005), 5 (P = 0.0000008), 6 (P = 0.0000008), 7 (P = 0.007), 8 (P = <0.0000001), and 9 (P = 0.0003). Instructor 2 had a significantly lower average than instructors 4 (P = 000002), 5 (P = 0.000003), 6 (P = 0.000003), 7 (P = 0.02), 8 (P = 0.0000008) and 9 (P = 0.001). Instructor 3 had a significantly lower average than instructor 8 (P = 0.01).

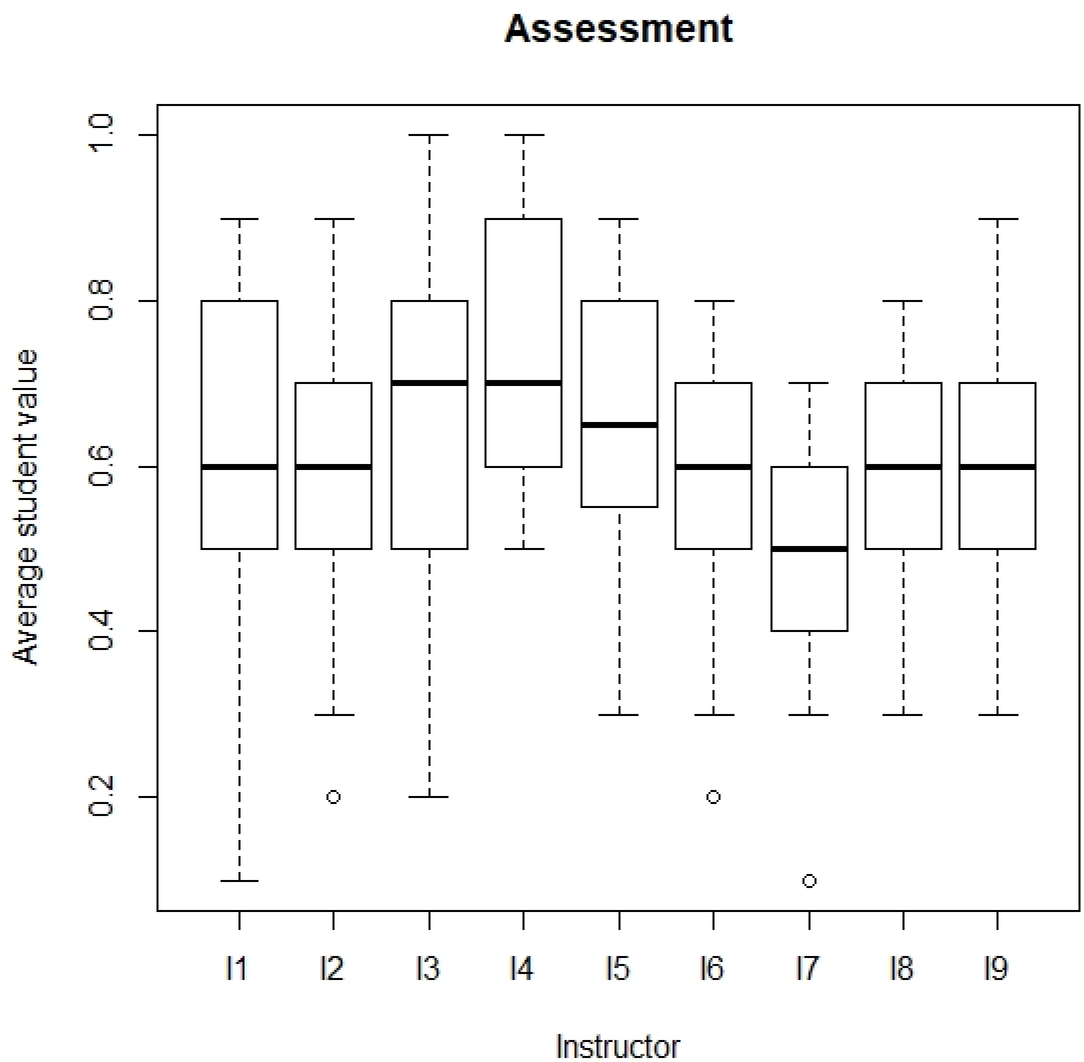

Figure 2.8. Instructors 1-5 consisted entirely of students who watched the supplemental videos while instructors 6-9 had students with no access to the supplemental videos. DF = 8, F-value = 5.078. Instructor 4 had significantly a higher average than instructors 1 (P = 0.04) ,2 (P = 0.01) ,6 (P = 0.005),7 (P=0.000006),8 (P = 0.009), and 9 (P = 0.04). Instructor 7 had a significantly lower average than instructors 3 (P = 0.007), and 5 (P = 0.02).

Conclusion

Both areas of research within this thesis were successful in providing new insights into their respective research areas. The results from these studies open new avenues of research that should be used in future studies.

The first study of this thesis provides evidence that makes it clear that South-Central Africa must be well represented in future studies as evidence shows it is potentially a part of the center of origin for kenaf. Many studies have neglected West and South-Central African samples, and this has led to them be underrepresented in kenaf center of origin studies. Future research needs to focus on defining the geographic range of kenaf's center of origin as East Africa is clearly not the only region that needs to be included. Data from this study has not made it possible to determine if kenaf underwent a single or multiple domestication events. Future studies should be able to address this by including more samples and more generating more data from those samples. The results from this study provide a great base for future studies to build from.

The second study of this thesis shows that using supplemental videos to help students learn may work, but also has drawbacks. If instructors implement supplemental videos, they should expect an increase in student academic performance, but should take measures to mitigate student confidence levels. Future studies could analyze different methods that the instructor can use to maximize any academic gains while also reducing student confidence loses. Perhaps teaching students about the Dunning-Kruger effect so they are aware of how increasing knowledge can reduce confidence, may make them less susceptible to that its effect. With research lacking in the field of supplemental materials and how they effect student confidence, this study offers a good base for future studies to build upon.

Vita

Justin Michael Hendy was born in Media, Ohio. He moved to Bel Air, Maryland when he was eleven years old. After graduating high school, he attended Miami University where he received a bachelor's degree in environmental science. After college he moved to Connecticut where he worked in an environmental testing laboratory called EMSL Analytical. He used several microscopy techniques to analyze various materials and air samples for the presence of asbestos. Working in a fast-paced laboratory setting led him to seek out further education. He went back to Miami University where he received a Master's degree in botany. His research was a morphometric revision of a species of clover, *Trifolium amabile*. After that he went to the University of Tennessee and received a Master's degree in biology. At the University of Tennessee, he honed his teaching abilities and received three teaching awards. With his teaching and laboratory experience he is pursuing employment that would utilize both of his areas of expertise.